Appendix A: Detailed description of the quantile mapping procedure

Let s be a location associated with some analysis grid point and x be a location associated with some forecast grid point in the vicinity of s. The basic idea of quantile mapping is to determine, for each forecast f_x, to which quantile $q_{f,x}(p), p \in [0,1]$ of the forecast climatology it corresponds, and then map it to the corresponding quantile $q_{o,s}(p)$ of the observation climatology. The quantile functions $q_{f,x}$ and $q_{o,s}$ are estimated from the training sample; specifically, we calculate the sample quantiles $\hat{q}_{f,x}(k/100)$ and $\hat{q}_{o,s}(k/100)$ for $k \in \{1, 2, \ldots, 99\}$, and interpolate linearly between these discrete values.

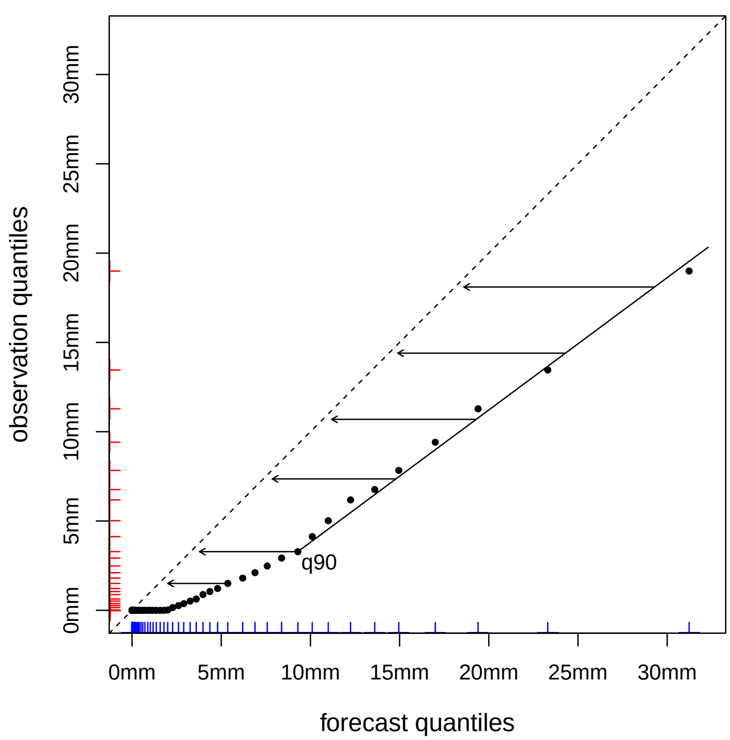
Since the variance of the sample quantiles strongly increases with increasing p, we only perform this direct mapping of (interpolated) sample quantiles for forecasts $f_x \leq \hat{q}_{f,x}(k_l/100), k_l = 90$. For $f_x > \hat{q}_{f,x}(k_l/100)$ we use a linear approximation of the quantile mapping function and define the adjusted forecast $\tilde{f}_x$ through

$$\tilde{f}_x := \max\left\{\hat{q}_{o,s}(k_l/100) + \xi \cdot \left(f_x - \hat{q}_{f,x}(k_l/100)\right), 0\right\} \tag{1}$$

This corresponds to a linear mapping function defined through the point $\left(\hat{q}_{f,x}(k_l/100), \hat{q}_{o,s}(k_l/100)\right)$ and the slope parameter ξ which is estimated via

$$\xi = \frac{\sum_{i=k_l+1}^{99} \left(\hat{q}_{o,s}(i/100) - \hat{q}_{o,s}(k_l/100)\right)\left(\hat{q}_{f,x}(i/100) - \hat{q}_{f,x}(k_l/100)\right)}{\sum_{i=k_l+1}^{99} \left(\hat{q}_{f,x}(i/100) - \hat{q}_{f,x}(k_l/100)\right)^2} \tag{2}$$

Moreover, it permits extrapolation for $f_x > \hat{q}_{f,x}(99/100)$. The following plot illustrates the mapping function for the quantiles corresponding to the right panel of Fig. 2 from the paper:



In this mapping procedure, we make sure that zero forecasts are always mapped to zero, and that none of the forecasts are mapped to a value larger than the largest observation at s.

At very dry locations, it can happen that either $q_{f,x}(90/100), q_{o,s}(90/100)$, or both are equal to zero. In this case we increase the k_l in eqns. (1) and (2) until both $q_{f,x}(k_l/100)$ and $q_{o,s}(k_l/100)$ are positive, and proceed as before. If either $q_{f,x}(99/100)$ or $q_{o,s}(99/100)$ are equal to zero, we set $\xi = 1$. Eqn. (1) then reduces to a purely additive adjustment:

$$\tilde{f}_x := \max\left\{f_x + \hat{q}_{o,s}(99/100) - \hat{q}_{f,x}(99/100), 0\right\} \tag{3}$$